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Optimization of Natural Adhesive Type and Concentration on Characteristics of Corn Cob Biobriquettes

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ABSTRACT

This study aims to evaluate the effect of wheat flour, starch, and sago adhesive variations on the characteristics of corn cob-based biobriquettes. Against the backdrop of fossil fuel scarcity and the abundance of corn cob waste, this research offers a solution to utilize the waste as an alternative fuel in the form of briquettes. The use of adhesives is an important element in the manufacture of quality briquettes. Adhesives not only play a role in maintaining the density of briquettes, but also affect the overall quality of the product. Different types of adhesives will result in different briquette quality, due to the different chemical compositions among the adhesives. The use of three types of adhesives with varying concentrations is expected to affect the quality of the briquettes based on SNI 01-6235-2000 standards. Testing the characteristics of biobriquettes includes moisture content, ash content, calorific value, and combustion rate. The results of this study found that the most optimal biobriquettes were 15% tapioca adhesive with the highest calorific value of 5563.13 cal/g, water content of 1.96%, ash content of 3%, volatile matter content of 5.76%, bound carbon content of 89.28%, and burning rate of 0.49 g/min. The biobriquettes have met SNI-01-6235-2000.

INTRODUCTION

The scarcity and rising prices of mineral fuels affect almost all levels of society, both industry and civil society. To avoid greater negative impacts due to the use of fossil fuels, the resulting biochar or biobriquettes can be utilized as an alternative fuel. One alternative fuel that can replace wood is biomass (Pangga et al., 2022). Indonesia has abundant resources. One of the natural resources of vegetable or biomass is corn. Based on the Badan Pusat Statistik (2023), the harvest area of shelled corn in 2023 is estimated at 14.46 million tons. The utilization of corn generally only utilizes pipil corn (corn kernels) then corn cobs will become waste that is not utilized.

Briquettes are a form of solid block that can be burned and serve as the primary fuel for starting and keeping fires burning. These briquettes come in many different types, including briquettes made from coal, charcoal, peat and biomass. In particular, biomass derived from agricultural sewage is frequently utilized as a key material for producing briquettes., as it is easily available in agrarian communities. The use of briquettes, especially biomass-based ones, is seen as a potential solution to replace fossil fuels that are becoming less available (Pangga et al., 2022).

Based on the Kabupaten Malang Satu Data (2023) source, the corn harvest area in Malang Regency is 54,766 hectares. Meanwhile, maize production in Malang Regency is 322,355 tons. With such an abundant amount of production, there is a potential for the accumulation of corn cob waste. Therefore, researchers chose corn cob biomass as a raw material for briquettes because in addition to utilizing unused waste, it is also an alternative to coconut shell raw materials which have high calorific value. Corn cob sewage can be utilized as raw material for making briquettes with a content of 23.74% lignin, 65.96% cellulose, and 10.28% hemicellulose (Sulistyaningkarti & Utami, 2017).

One of the factors that affect the characteristics of biobriquettes is the adhesive. Various previous studies have examined the use of different types of adhesives and different concentrations of adhesives on the characteristics of biobriquettes. In addition to biomass, the use of adhesives is an important element in making quality briquettes. Adhesives not only play a role in maintaining the density of the briquettes, but also affect the overall quality of the product. Different types of adhesives will result in different briquette quality, due to the different chemical composition among the adhesives (Mahadi, Zulfarina & Panggabean, 2023).

Sulistyaningkarti and Utami's research has conducted research on the manufacture of corn cob biobriquettes using the independent variables of adhesive types of tapioca flour and wheat flour. The concentrations used were 5%, 10%, and 15%. The research resulted in the best moisture content, ash content, volatile matter content, bound carbon content, and calorific value of 5% tapioca adhesive (Sulistyaningkarti & Utami, 2017). Research by Pangga et al. has conducted research on the manufacture of corn cob biobriquettes with independent variables, namely adhesive concentrations of 5%, 10%, and 15% with the geometric shapes used, namely tubes and boxes. In the study, the best calorific value was produced in the form of a box with 5% adhesive producing a calorific value of 6800 cal/g (Pangga et al., 2022).

Amrullah and Oktaviananda's research has conducted research on the manufacture of corn cob biobriquettes with independent variables, namely glutinous rice flour with concentrations of 0%, 3%, 4%, and 7%. The study produced the best water content and calorific value at 0%, the best ash content at 3%, and the best destruction index at 4% (Amrullah & Oktaviananda, 2023). Haryono's research has conducted research on the manufacture of corn cob biobriquettes with independent variables, namely the weight ratio of charcoal to PET 95: 5 (B1), 90: 10 (B2), and 85: 15 (B3). The research resulted in the best calorific value, moisture content, and ash content at a ratio of 85:15 (B3). And the best vapor content is the ratio of 95:5 (B1) (Haryono, 2020). Rifdal et al. have conducted research on the manufacture of corn cob biobriquettes with independent variables, namely the type of glue, flour, and soil adhesive with the amount of adhesive 25, 30, 35, 40, and 45 grams. In this study, the best ash content, moisture content, and calorific value were 25 grams of glue adhesive (Rifdal et al., 2017).

The main process in making biobriquettes is the carbonization process. Based on Widarti's research, biobriquettes from corn cobs have been made to increase the calorific value. The carbonization process carried out is using 200-300ºC for 1 hour. The charcoal obtained will pass the 60 mesh sieve. With the independent variable of corn cob: rice husk ratio. The result of the research is that the calorific value of corn cob is quite high, but the addition of rice husk results in a decrease in calorific value (Widarti et al., 2016).

This research provides a new approach by comparing types of natural adhesives (wheat flour, tapioca, and sago) at more varied concentrations, thus providing new insights in optimizing the characteristics of biobriquettes. This is because there is still no other research that compares the three types of adhesives directly. This study aims to evaluate the effect of variations in the type and concentration of natural adhesives on the characteristics of corn cob-based biobriquettes according to SNI 01-6235-2000 standards related to water content, ash content, volatile matter content, bound carbon content, calorific value, and burning rate.

RESEARCH METHODS

Tools and Materials

The tools used are briquette printing equipment, carbonization equipment, 60 mesh sieve, beakerglass, porcelain cup, desiccator, furnace, grinder, hotplate, porcelain crucible, baking sheet, digital balance, oven, knife, stirrer, basin container. The materials used were corn cobs, water, wheat flour (segitiga biru brand), starch (merek rose brand), and sago flour (mahkota keong brand).

Variable

The variables used in this study are control variables consisting of a temperature for carbonization of 300°C, the duration of carbonizatio is 1 hour, a press pressure of 100 bar, size of a briquette particle ≥60 mesh, and a charcoal powder: water ratio of 1. 2: 2. As well as independent variables in the form of wheat flour, starch, and sago flour with concentrations of 5%, 10%, 15%, 20%, and 25%.

Prosedur

1. The carbonization process of dried corn cobs using a carbonization device with a temperature of 300°C for 1 hour. The charcoal that has been obtained is crushed with a grinder.
2. In the Grinder tool, the corn cob charcoal is crushed until it becomes powder with a size of ≥60 mesh.
3. Carbon powder that has been sized ≥60 mesh will be mixed with several adhesives with a certain concentration and boiling water is added. Then stirred until the dough is smooth. Then enter the briquette molding stage.
4. After the briquettes are molded, they are cooled at room temperature for 2 days.
5. Briquettes that have dried and solidified, will be tested in the form of water content test, ash content test, volatile matter content test, bound carbon content test, calorific value test, and combustion rate test.

Water Content

To determine the water content according to SNI-01-6235-2000, the test sample in the form of biobriquettes is weighed about 1 gram. The sample was heated in an oven at 115°C for 3 hours. After that, the sample was weighed again. The water content is calculated using the following formula:

$$\text{Water content (\%)} = \frac{\text{Weight of initial sample - Weight of sample after drying}}{\text{Weight of initial sample}} \times 100\% \quad (1)$$

Ash Content

To determine the ash content according to SNI-01-6235-2000, porcelain crucible without lid with biobricks test sample weighed as much as 2 grams. Then the sample was heated at 450-500°C for 1 hour, then at 700-750°C for 2 hours, then continued to ashing at 800-900°C for 2 hours. Cooled the porcelain crucible using a desiccator and weighed. Ash content was calculated based on the following formula:

$$\text{Ash content (\%)} = \frac{\text{Crus weight and ash - Crus empty weight}}{\text{Sample weight}} \times 100\% \quad (2)$$

Vollatile Matter

To determine the vollatile matter according to SNI-01-6235-2000, porcelain crates without lids with samples of water content test results are weighed. Next, the samples were heated at 950°C for 7 minutes, then cooled in a desiccator and weighed. Vollatile matter is calculated based on the formula:

$$\text{Vollatile matter (\%)} = \frac{\text{Weight of sample before - Weight of sample after}}{\text{Weight of initial sample at moisture content}} \times 100\% \quad (3)$$

Bound Carbon Content

To determine the bound carbon content of biobriquettes according to SNI-01-6235-2000, it is calculated using the formula:

Bound carbon content (%) = 100 – (water content + ash content + vollatile matter) % (4)

Caloric Value

The calorific value was measured using a calorimeter bomb.

Burning rate

The burning rate of the briquettes was measured with a stopwatch, recording the time until maximum heat was reached. Analysis involved the duration of burning to the maximum temperature as well as the mass of the briquettes after they were extinguished and weighed. The data is then used in calculations. Measuring the burning rate using the formula:

$$\text{Burning rate (gram/menit)} = \frac{\text{Initial briquette mass - Residual briquette mass}}{\text{Burning time}} \quad (5)$$

RESULTS AND DISCUSSION

Figure 1. Corn cob biobriquettes

Figure 1 is the result of the process biobriquettes during the research. Biobriquettes that have been processed, obtained quite good results in terms of shape because they use printing equipment with the same pressure and evenly distributed, namely 100 bar pressure. The testing process is carried out to determine the results of the research. The results will show whether the biobriquettes that have been made are in accordance with standard SNI-01-6235-2000 or not. The testing process consists of moisture content, ash content, volatile matter content, bound carbon content, calorific value, and combustion rate.

Water Content

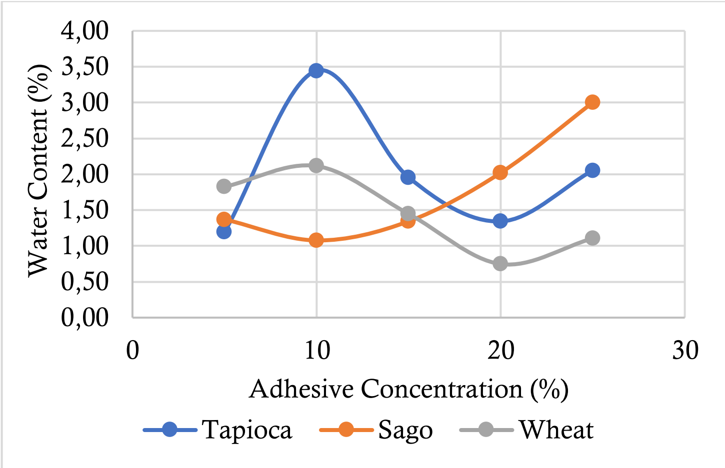

Figure 2. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on water content

According to Figure 2, the findings indicate that the highest moisture content is tapioca 10% with a moisture content of 3.44% and the lowest is wheat 20% with a moisture content of 0.75%. The content of the adhesive greatly affects the moisture content. The moisture content in tapioca adhesive is quite high due to the high content of amylose and amylopectin which causes the gelatinization process. Water trapped in gelatin will be difficult to evaporate (Cholilie & Zuari, 2021). The graph shows inconstant results due to several factors in terms of room humidity and uneven drying and rainy season weather. However, all the test results of the biobriquette content show that it is in compliance with the SNI-01-6235-2000 standard, which is ≤ 8%.

Ash Content

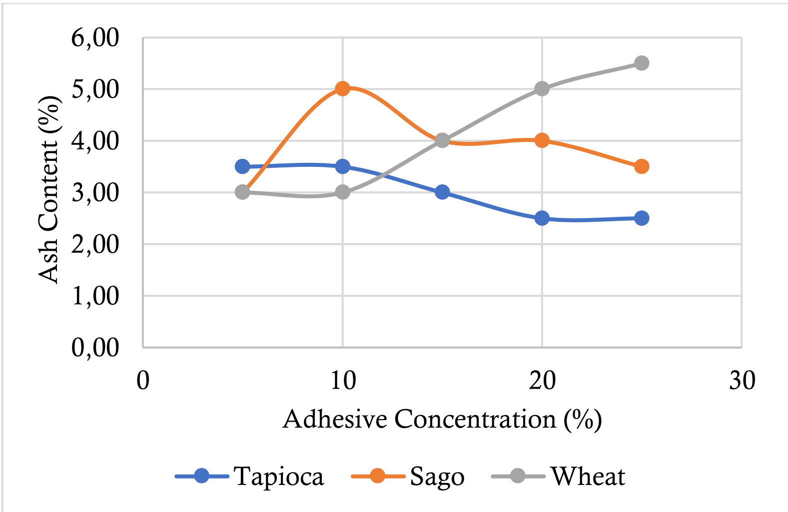

Figure 3. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on ash content

According to Figure 3, the findings indicate that the highest ash content is 25% flour with a level of 5.5% and the lowest is 25% tapioca with a level of 2.5%. High ash content in flour indicates that there are contaminants. The more contaminants such as minerals in flour, the higher the ash content (Kinanthi Pangestuti & Darmawan, 2021). In the graph, it can be seen that the results are not constant up or down because the different and inconstant water content will produce inconstant ash content as well. Nevertheless, the results showed that all biobriquettes were still in compliance with the SNI-01-6235-2000 standard of ≤ 8%.

Vollatile Matter

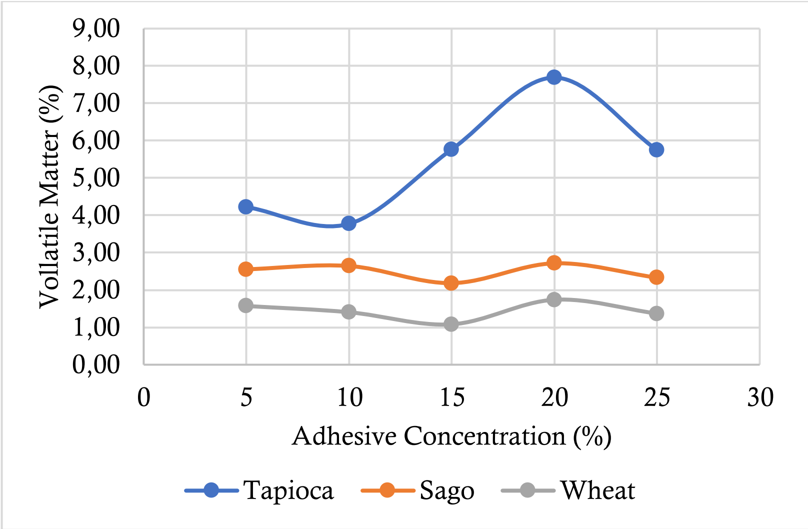

Figure 4. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on vollatile matter

According to Figure 4, the findings indicate that the lowest vapor content is 15% flour with a level of 1.08% and the highest level is 20% tapioca with a level of 7.69%. The content of volatile matter will affect the combustion perfection. The higher the vaporized substance, the faster the combustion rate will be and cause quite a lot of smoke (Anizar et al., 2020). The graph shows that of the three adhesives, tapioca has a high volatile substance so that the combustion rate will be a larger gram every one minute. This will be proven in the combustion rate test. It can be seen that the results are not constant up or down due to the water and ash content which is not constant either. Nevertheless, all test results are still classified as In compliance with the SNI-01-6235-2000 standard ≤ 15%.

Bound Carbon Content

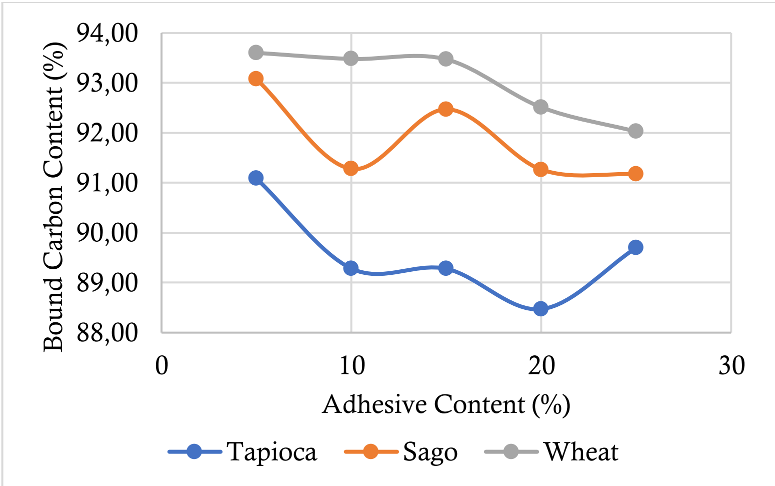

Figure 5. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on bound carbon content

According to Figure 5, the findings indicate that the highest bound carbon content is 5% wheat flour with a level of 93.60% and the lowest is 20% tapioca with a level of 88.47%. The content of bound carbon in biobriquettes is influenced by the amount of moisture content, ash content, and volatile substances contained in the biobriquettes. The more adhesive the bound carbon content will decrease (Abdillah & Siregar, 2024). This is also evidenced from Nugraha's research, that there is a decrease in bound carbon content as the percentage of the amount of adhesive increases due to more water content (Irawansyah et al., 2022). All results are still in the SNI-01-6235-2000 standards ≥ 69%.

Caloric Value

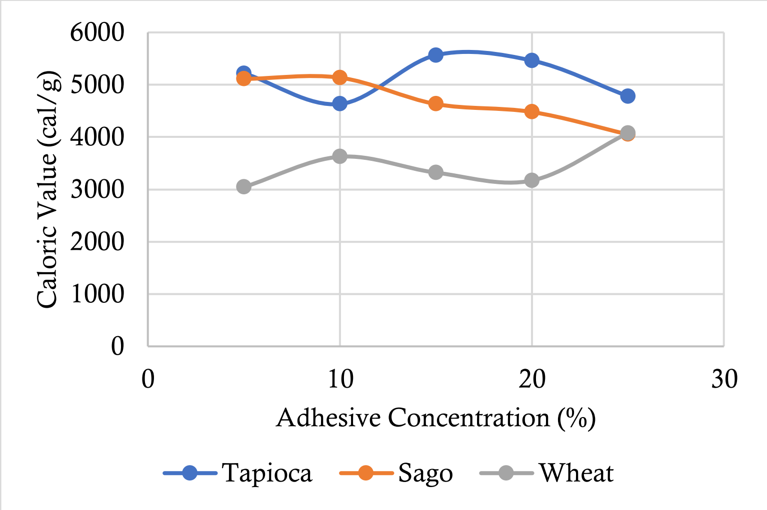

Figure 6. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on caloric value

According to Figure 6, the findings indicate that the highest calorific value is 15% tapioca with a calorific value of 5563.13 cal/g and the lowest is 5% wheat with a calorific value of 3043.56 cal/g. Tapioca adhesive has a higher calorific value than sago and wheat due to the higher amylose and amylopectin content that makes the adhesion of biobriquettes better. The impact makes the calorific value higher (Jayana & Evila Purwanti Sri Rahayu, 2022). The test results obtained that meet the SNI-01-6235-2000 standard ≥ 5000 cal/g are only a few, namely tapioca 5%, 15%, 20%, sago 5%, and 10%. In addition, it is still below the SNI-01-6235-2000 standard due to the lack of adhesion to the briquette and the high water content makes the calorific value go down.

Burning Rate

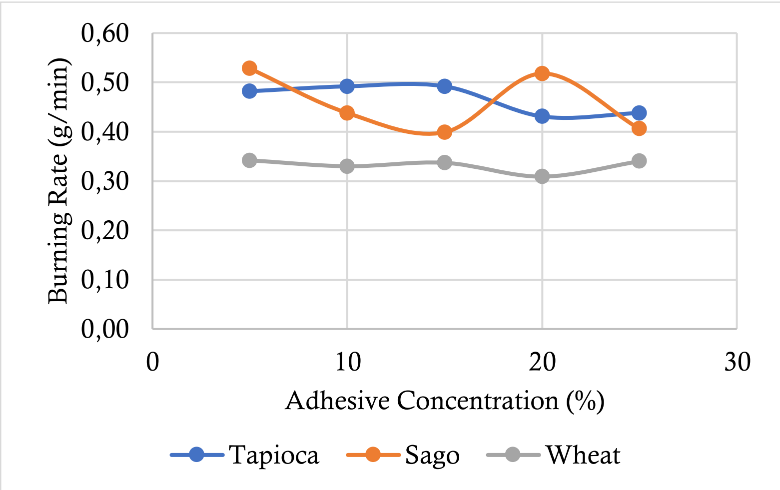

Figure 7. Graph of the relationship between the concentration of tapioca, sago, and wheat adhesive on burning rate

According to Figure 7, the findings indicate that the results showed that the highest burning rate was 5% sago with a pace of 0.53 g/min and the lowest was 20% wheat with a pace of 0.31 g/min. The burning rate of briquettes will be higher if the water content of the briquettes is high, causing heat transfer to the surface of the briquettes to spread evenly (Aljarwi et al., 2020). The results show that wheat flour has a better burning rate than tapioca and sago due to the influence of moisture content.

CONCLUSION

This series of studies resulted in several conclusions related to the results of testing biobriquettes. Tapioca flour and sago have the same characteristics for the water content parameter, the higher the concentration of adhesive, the higher the moisture content. Wheat flour, on the other hand, is the opposite. However, the characteristics of tapioca differ from sago and wheat in that the higher the adhesive concentration, the greater the ash content. Wheat has low volatiles compared to tapioca and sago. The lowest amount of water, ash, and volatile matter causes the bound carbon content to be quite high. In addition, the more adhesive, the lower the bound carbon content. Tapioca adhesive has a higher heating value than sago and wheat due to its higher amylose and amylopectin content. In the combustion rate parameter, the less biobriquettes burned in one minute, the better the biobriquettes because they are more durable during the combustion process. The results showed that the lower the water content, the higher the ash content and volatile matter content. This affects the bound carbon content and calorific value as well as the combustion rate. In addition, it is concluded that tapioca and sago have the same characteristics of various parameters and meet the SNI-01-6235-2000 standard more than wheat. Biobriquettes that meet the SNI-01-6235-2000 standard can be applied on a household and industrial scale. On a household scale, it can be used as fuel for grilling food, while on an industrial scale it can be used as industrial fuel.

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